LETTERS TO THE EDITORS

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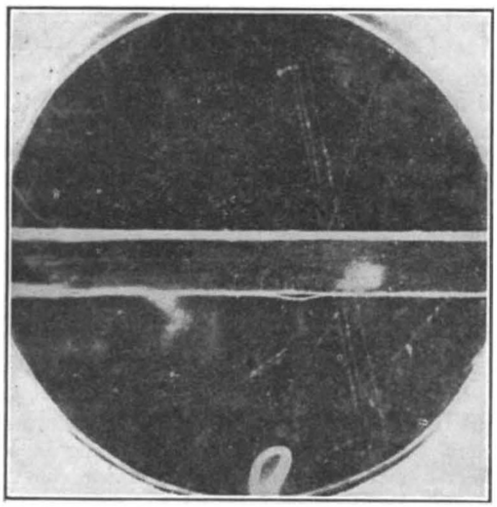
Cloud Chamber Investigation of Penetrating Showers

THE existence of penetrating showers, different from electron cascades or knock-on showers, has been established by counter experiments[1,2]. These experiments are most easily interpreted in terms of showers containing several penetrating particles, though other interpretations cannot be excluded[3].



To investigate the nature of these penetrating showers, we have used a deep cloud chamber controlled by a counter system selective for penetrating showers. The counter system consists of three trays each containing two counter sets. The expansions are controlled by sixfold coincidences, namely, coincidences between six counters, one out of each set. The trays are separated by lead absorbers of sufficient thickness to cut out cascade showers. The total thickness of absorber is 30 cm. The cloud chamber is placed between the top tray and the middle tray. In order to distinguish electrons from penetrating particles, a lead plate 2·3 cm. thick is placed across the middle of the chamber.

The rate of sixfold coincidences is 8 ± 1 counts per 100 hours and is due to the following processes: (1) penetrating showers, (2) triple knock-on showers, (3) casual coincidences. The rate of (2) is estimated as 0·7 counts per 100 hours, while that of (3) as 0·5 counts per 100 hours. Thus most of the observed coincidences should be due to penetrating showers.

One of our photographs, reproduced herewith, shows three penetrating particles traversing the lead plate. The stereoscopic projection shows that the three tracks diverge from a point situated in a lead absorber of 2 cm. thickness which is placed over the top counter tray. A somewhat similar photograph has been reported recently by Powell[4]; pairs of penetrating particles have been reported by various observers[5]. A pair of penetrating particles may consist of a meson and knock-on proton, but this explanation is excluded if there are more than two penetrating particles. Three penetrating particles originating from one point indicates the occurrence of multiple processes.

The accompanying table contains a classification of 32 photographs.

Total number of photographs	Photographs with definitely more than one penetrating particle	Photographs with probably more than one penetrating particle	Photographs with one penetrating particle	Big showers	Unclassified photographs
32	2	3	6	4	17

We know from other experiments that the extension of penetrating showers is large compared with the area covered by the cloud chamber and therefore only a fraction of the penetrating particles in any shower is photographed. Further, the density of tracks in the photographs classified as 'big showers' is so great that it is impossible to say whether or not they contain penetrating particles. The photographs obtained may, therefore, be considered compatible with the view that all penetrating showers contain associated penetrating particles. In any case, we can conclude that a not inconsiderable fraction of the penetrating showers contains associated penetrating particles.

It appears from the photographs that the penetrating showers do not consist simply of simultaneous mesons, but are rather complex.

The thirty-two photographs obtained show nine heavily ionizing tracks due to slow mesons or slow protons. Though heavily ionizing particles are known to occur in showers[6], the rate of heavily ionizing particles per photograph in the present investigation is rather high. It seems therefore that the heavily ionizing particles are connected with the penetrating showers.

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[1] Wataghin, Santos and Pompeia, *Phys. Rev.*, **57**, 61–339 (1940); **59**, 902 (1941).
[2] Jánossy and Ingleby, NATURE, **145**, 511 (1940).
[3] Jánossy, *Proc. Roy. Soc.*, A (in the press).
[4] Powell, *Phys. Rev.*, **60**, 413 (1941).
[5] Braddick and Hensby, NATURE, **144**, 1012 (1939); Herzog and Bostick, *Phys. Rev.*, **58**, 218 (1940); Powell, *Phys. Rev.*, **58**, 474 (1940).
[6] Blackett and Occhialini, *Proc. Roy. Soc.*, *A*, **139**, 699 (1933); Anderson and Neddermeyer, *Phys. Rev.*, **50**, 263 (1937).